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Integrating web applications to provide an effective distance online learning environment for students

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Abstract

The Human Physiology online course offered by the Department of Physiology at the University of Toronto (www.physiology.utoronto.ca) offers a quality online learning experience and promotes flexibility to its students in terms of time and location, allowing self-directed learning within a semi-structured frame-work. The online course population has expanded, including a more heterogeneous group of students. In addition to the traditional pre or current healthcare professionals (post-secondary students), there are now international students, working adults seeking career advancements, teachers, and even those just taking the course for personal interest. The course aims to use web tools to support and increase accessibility for all of these educationally and socially diverse students. Course material for students consists of 51 didactic lectures delivered in a video format (available to students for 24 hours, each day of the week for streaming) and a virtual lab experience. There are several sources of course support for students such as a 24/7 discussion board that is monitored by instructors and teaching assistants (an academic and peer support network), virtual tutorials with a teaching assistant (java applet chat) and instructors are always available to students by email. Frequent online quizzes were another feature that was very effective in both enhancing learning experience and improving student performance.

Analysis of student data, student surveys and course evaluations from the online course suggested it was just as, if not more effective than the in-class course equivalent. The framework of this course can be easily adapted in creating an online course in any post-secondary discipline.

Keywords: online, distance, education, learning, physiology

1. Introduction

Focus on education has become an absolute priority (career reasons, personal thirsts for knowledge etc.) [1]. With rising pace, technological literacy has also rapidly increased in the last decade. As a result, online courses have become more in demand than ever [2]. Distance learning provided by universities is no longer only restricted to students who want to take a course that they physically cannot attend. The online student population has expanded beyond just post-secondary students within the continent. This includes but is not limited to parents who would like to boost their credentials from home, employers interested in continued education for their employees (e.g. healthcare sector), international students and educators eager to experience North American teaching styles, teachers and home-schooling parents who want to expand their knowledge to teach an unfamiliar subject and even retired

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adults who simply want to take a course for personal interest [3]. Educators creating these courses need to cater their methods of delivery to their audience to best benefit the diverse student population [4].

In light of rising student needs, the University of Toronto created the online Basic Human Physiology course (online PSL course) for the diverse student set requiring (as a credit etc.) or interested in human physiology. The online course consists of 51 online didactic lectures and corresponding topic-related "virtual labs" that involve computer simulations. Video platforms and multimedia broadcasting allow us to make the lecture content available to students 24 hours a day though streaming. The course also incorporates online student support through powerful social and collaboration tools (chat, discussion forums, and online webcam services) to facilitate communication between students and provide guidance from instructors and teaching assistants (TA).

Our study focuses on how web applications and online course features have benefitted student learning. From our research, we have learned that students found the online course provided them flexibility and the freedom of self-directed learning without compromising them in anyway academically. Comparing the online PSL course to the in-class course equivalent, the online course was just as effective as the in-class course for student performance (grades) and success (achieving their goals for the course). However, students have noted a greater level of support and collaboration available for their learning in the online course. Moreover, we found that simple strategies like incorporating frequent online quizzes (something that is difficult to do in in-class courses) proved to be extremely effective in enhancing the learning experience. We also found that taking full advantage of the voluntary discussion board and virtual tutorial (TA) participation was crucial to the students' success.

As we enter the technological age, the general public has changed their methods of learning and acquiring information to adapt to the wealth of technology available, and the technology has changed for the public to become more easily accessible and user friendly [2]. Many of these internet tools are not education specific but as we have found, with the right integration by educators they can become valuable resources for students.

2. Rational

Active application and a concrete understanding of human physiology are essential for students planning on pursing application or completion of healthcare programs [5]. However, many of these students may have been working already and/or have families to care for [6]. A full time course on campus was discouraging for many of our busy adult students. Thus, we introduced the new online format of the on-campus course to provide students flexibility and convenience in time and location.

After six sessions of administrating and improving the online course, it has left us wondering, has it actually worked? Do the students learn the same material just as well in the online format? How does the new online course compare to the in-class format in the past? Was the lecturer able to convey the course material just as effectively? What was the impact of the lecturer on the learning experience? Did the course actually improve student accessibility? Did it allow more self-directed learning and convenience to students? In light of all these unanswered questions, this study aims to explore the student learning experience and their performance in this online physiology course.

3. Methods

3.1 Online Course Design

The online PSL course was designed with the in-class physiology course as a basis. Both courses have 51 didactic lecture hours and an "active learning component which comprises 12 computer laboratory simulations. ePresence (with embedded Flash) was the multimedia platform used to launch the web-lecture series. The videos were available to students wherever a computer and the internet could be accessed. Lecturers would teach facing the camera directly while they clarified concepts to students as though they were teaching them "one-on-one." This is an experience that is impossible to achieve in the in-class format with a lecture hall of approximately 300 students. Three 50 minute lecture videos were released to students each week (midnight on Sunday) to be streamed at their leisure, however many times they needed and at anytime of the day. However, to enforce the same level of discipline as the in-class course, the three lecture videos would be taken off the website at the end of the week. Lecture slides were also available to students, to download and make more extensive notes.

Collaboration tools (chat, a discussion board) allowed communication between students, formation of student study groups as well as assistance with course material from lecturers and the TA. For instance, the discussion board (available 24/7) served as a mutual area for the class to express any questions, concerns or support for their peers. Lecturers and the TA consistently monitor the discussion board to provide answers, student guidance and ensure the information on the discussion board is accurate. The TA also arranged a time suitable for the majority of students to have a virtual tutorial (a Java Applet: chat and drawing tool), a classroom feature popular for students to reinforce what they learn from lectures with a TA. Participation via the discussion board was afforded 5% of the student's final mark. Direct communication to lecturers by email was also available if needed and since the entire course was online, questions were attended to more quickly than the in-class course.

Student assessment was very similar to that of the in-class format. There is a final exam (worth 50% of each student's final grade) written in person at a test center closest to their home. The examination consisted of multiple-choice questions (MCQs) that are similar to the in-class exam format. In addition, to the exam, there are five online quizzes that contributed towards the term mark, accounting for 45% of the final grade. The quizzes provided some flexibility for the students in that the quiz was offered for 24 hours on a particular day. To ensure that the quizzes had similar integrity and validity expected of all post-secondary level assessments, they were timed for 30 minutes and once the quiz started, it could not be paused or stopped. Students had to complete 20 MCQ's within the 30 minute timeframe. They would receive a grade depending on how many correct answers they had completed within the timeframe. Participation in the course (discussion board, virtual tutorials) enabled students to receive 5% towards their final grade.

Whereas the in-class course is offered over a year's time due to student course scheduling at the University of Toronto, the online PSL course can flexibly be offered in semester segments. Though the material taught in both formats is essentially the same, the online course covers the material in half a school year's time (four months) while the in-class course teachers the material over in one school year's time (eight months). Thus the convention for the online PSL course sessions is slightly different (*Table 1*).

Table 1. The six online PSL sessions administered as of August 2010. The fall semester refers to the time period from October to mid-February, winter semester refers to the time period from January to mid-May and the summer semester is from May to mid-August.

Session	***Course Length***
001	Fall 2009
003	Winter 2009
002	Summer 2009
004	Fall 2010
005	Winter 2010
006	Summer 2010

3.2 Grades analysis (in-class course versus online course)

Grades from in-class PSL course, (2006-2009) were compared to the grades obtained from the six sessions of the online PSL course (Fall 2009-2010). Grades were statistically analyzed ($\alpha = 0.01$). Students who successfully completed the course were required to master the basic human physiology concepts in *Table 2*.

Table 2. The primary learning objectives and organization of the course material

Syllabus and Course Objectives
Cell Physiology and Homeostasis
Describe the principles of homeostasis
Nervous System
Describe nerve impulses and action potentials Describe the mechanism of synaptic transmission Describe the function of the central nervous system Describe the mechanism of sensory systems
Endocrine System
Describe hormone actions and their receptors Describe the functions of hormones secreted by the glands Describe hormonal regulation and reproduction
Musculoskeletal System
Describe the generalized functions of skeletal muscle tissue
Cardiovascular System
Describe the function (and related anatomy) of the cardiovascular system Describe nervous and hormonal control of cardiac function Describe the factors involved in the regulation of arterial blood pressure
Blood and Immunity
Describe blood composition and function Describe non-specific Immunity Describe specific Immunity and transfusion reactions
Respiratory System
Describe the principles of gas exchange in the alveoli Describe respiration and exercise
Renal System
Describe the functions (and related anatomy) of the kidney Describe filtration, reabsorption, and secretion Describe the regulation of fluid and acid-base balance in the body
Digestive System
Describe the absorption of nutrients from the GI tract Describe the nervous and hormonal regulation of digestion

3.3 Traditional student evaluation (survey): Students enrolled in the traditional in-class PSL course were given anonymous evaluations where the students were asked to rate the lecturers and the course. The students (2006-2009) were asked to fill out detailed information regarding the lecturers and the course and examples of these questions are shown in *Table 3*.

Table 3. Examples of traditional in-class survey questions

Lecturer evaluation	
Question 1	Communicates goals and requirements of the course clearly and explicitly
Question 2	Presents material in an organized, well-planned manner
Question 3	Explains concepts clearly with appropriate use of examples
Question 4	Communicates enthusiasm and interest in the course material
Question 5	All things considered, performs effectively as a university teacher

3.3 Online student evaluation (survey):

Similar to the in-class course, students enrolled in the online PSL course were allowed five separate anonymous surveys where they can express their opinions about the course and rate the lecturers. For the online course however, students were asked to compare online course experience with on campus courses that they have taken in the past. Questions regarding the lecturers were virtually identical to the ones asked in the in-class surveys but additional questions were also added to provide a guideline to compare the online course to the in-class course (*Table 4*). Students were also surveyed with questions about the course's technological features and collaboration tools in the online course to gage areas of improvement (*Table 5*). Moreover, the online survey included questions to determine the impact of social and peer support on student learning (*Table 6*). It has been suggested that the learner-learner (peer) interaction is just as, if not more important than instructor-learner interaction [7]. Finally, the use of open-ended questions in the survey gives students a chance to express their feedback about the course. Armed with the new experience of learning in this online medium, students could comment on which aspects of the course were positive (should be retained), negative (should be taken out) and what types of needs should be addressed or features need to be added.

Table 4. Examples of online survey questions pertaining to the lecturers

Lecturer Evaluation	
Question 1	Did the lecturer present clear objectives?
Question 2	Did the lecturer present material clearly, and in a logical, organized manner?
Question 3	Were the terms and concepts clearly defined or explained?
Question 4	Did the lecturer convey enthusiasm and interest in the topics presented?
Question 5	What is your overall rating of this lecturer's contribution to your learning experience?

Table 5. Examples of online survey questions pertaining to the course organization or in general

General Course Evaluation	
Question 1	Did your professor respond to your concerns in a timely manner?
Question 2	Were the discussion board and the virtual TA hours helpful?
Question 3	Did the lecturer/TA address the questions of students effectively?
Question 4	Was the course material provided well-detailed?
Question 5	Based on your experience with this course, would you take another Web-Course from University of Toronto?

Table 6. Examples of online survey questions focusing on the learner-learner interaction

Peer Interaction And Collaboration	
Question 1	Did you find the course provided a positive social experience?
Question 2	Did you contact other students from the course to study further or not?
Question 3	Would you like to have more interactive experiences in the course?
Question 4	Would you like more opportunity to interact with TA[1]s on practice problems?
Question 5	Would you like more opportunity to interact with peers to work on practice problems?

Table 7. Examples of open-ended questions in the online survey

Open-ended Questions	
Question 1	If you could suggest an additional interactive experience in the course that would enhance your understanding of the material, what would that be?
Question 2	Please provide us with any additional comments and/or suggestions

3.5 Online course participation and student score

The online PSL course was offered using the Blackboard Software (Blackboard Inc.) which allowed automated data collection on student activity in various features of the course such as the discussion board and virtual tutorials. The data consists of the number of times and length of time the feature has been used by an individual. This data have allowed us to compare and correlate student participation (via discussion board and virtual tutorials) to the students' score

4. Results

4.1 Class Demographic

Through six sessions of the online PSL course, it was discovered that the student population contains a majority of pre-health care program applicants (*Fig. 1*). This large population in the course can then be broken down into students who have recently or have yet to earn a degree versus adult learners/parents who are already or once were working. Our study of student demographic was mainly anecdotal, observed by researchers on the discussion board or students revealing the information voluntarily via email or some form of electronic means. An ethical submission was accepted for this study, which does not permit gathering of information pertaining to individual student backgrounds (race, age, family status, employment etc.). Thus, the demographic study is purely an educated estimate* from lengthy research observations and voluntary student participation. The online PSL class size typically ranges from 27 to 53.

The traditional in-class course however, mostly consisted of students who were already in a healthcare or specialty program such as pharmacy or physical education. The class size typically ranges from 226-267.

Fig. 1. An estimate* of the student population typically taking the online PSL course and some of their reasons for taking the course.

4.2 Grades Analysis

Student grade data from the in-class PSL course (2006, 2007, 2008 and 2009) and the online PSL course (2008-2009, session 001 -006) were compared and analyzed. Although in-class PSL course has nearly 300 students year, similar to the online PSL course, the course average is generally around 67% (*Fig. 4*). The results seem to suggest that there are virtually no significant differences in the class averages between the traditional in-class courses and the online PSL course despite the fact that the student population in the two classes is extremely diverse (*Fig. 1)*.

When the students' letter grades of the in-class PSL course and the online PSL course were compared, it was discovered that the distribution of grades are very similar. There are a few number of students with As and Bs and the majority of students are in the C grade range. Furthermore, we have found that only a very small percentage of students in both versions of the course have obtained an F grade (*Fig. 2*). This seems to reflect the traditional grade distribution found in most post-secondary institutions such as that of the University of Toronto [7].

An observation of the distribution of online quiz grades from the online PSL course and seems to show an increasing learning curve as evidenced by an increase in class average from quiz 1 to 4 (*Fig. 3*)

Fig. 2. The online PSL course class mean over the six different classes/sessions (N= 43, 28, 27, 53, 52, 52 respectively)

Fig. 3. The 002-class average from the online assessment (timed online quizzes) throughout the course

Fig. 4. The online PSL course average (mean of six sessions) is compared to the in-class format (2006-2009, $N_{in\text{-}class}$=233, 267, 226 respectively). There is no significant difference in student grades between the online and the in-class format ($F<F_{critical}$, $P<0.05$, $\alpha=0.05$)

4.3 Online Evaluation (Survey)

Lecturer performance was rated and compared between the online PSL course and the in-class course. The results seem to indicate that in most part, there were no significant differences in the lecturers' performance and delivery in the online format as opposed to the traditional in-class course (*Fig. 5*). Students also found the level of difficulty and depth of the content taught in the course to be within their expectations of a university level course (*Fig. 6,* where N corresponds to the number of students who participated in the online survey*).* Also, 90.64% of students rated the course as a valuable learning experience (Fig. 7). In figure 8, 68.42% of students rated the lecturers favourably in terms of contribution to their learning. Furthermore, Figure 9 suggests that the majority of students who took the online PSL course (76.5%) found the experience positive and would likely take another online course from the University.

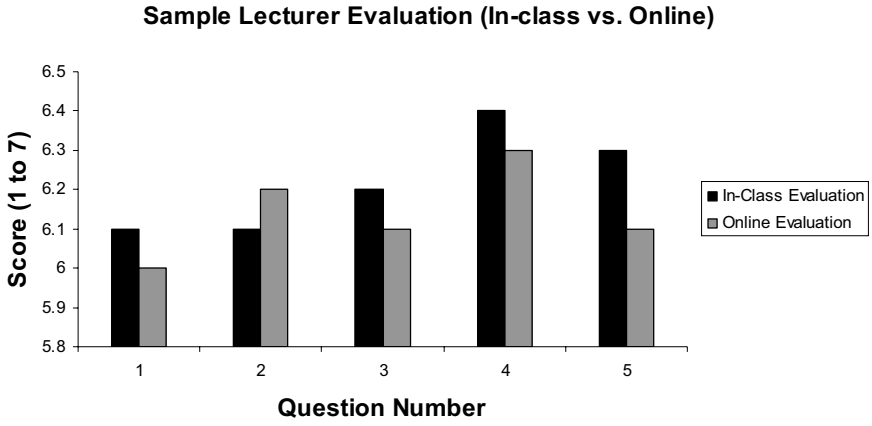

Fig. 5. A comparison of the online (Class 001) rating and in-class rating of the same lecturer:

- Question 1: Did the lecturer present clear objectives?
- Question 2: Did the lecturer present material clearly, and in a logical, organized manner?

- Question 3: Were the terms and concepts clearly defined or explained?
- Question 4: Did the lecturer convey enthusiasm and interest in the topics presented?
- Question 5: What is your overall rating of this lecturer's contribution to your learning experience?

Fig. 6. Student response to the actual depth of learning in the online PSL course compared to their expectations of other post-secondary level courses (005 Class, N=33)

Fig. 7. Students express how they felt about the course as a learning experience (005 Class, N=34)

Fig. 8. Student thoughts on the online PSL course lecturers and their contribution to individual learning (005 Class, N=33)

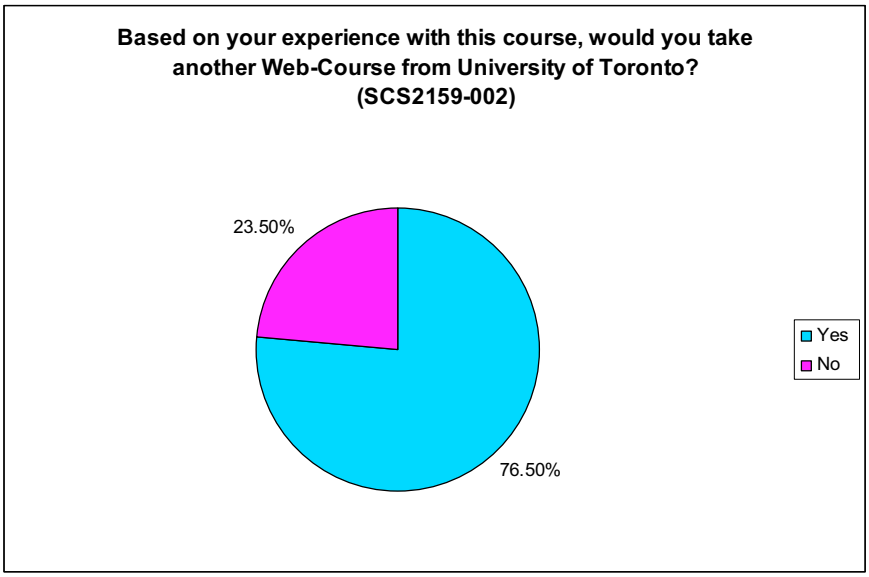

Fig. 9. Whether students take another online course again based on their experience in the online PSL course (002 Class, N=26).

Table 8. Open-ended responses and suggestions

Positive comments	*Negative comments*
I found the discussion board to be very useful and I appreciated Dr. K's quick and resourceful responses. I felt like all of our concerns and questions were considered important and it was great to get things resolved quickly.	Having a break between the release of the last set of lectures and the final exam would be beneficial.

This was by far the best unit. The professor was dynamic and interesting to watch. The material was presented in a fun and practical manner. Great course!	Provide sample practice questions prior to quizzes.
I believe that the team is on the way in producing a very successful course. I am happy to have participated.	There should be a break between the release of the last set of lectures and the final exam; this would enhance our preparation for the final.
I found his lectures more interactive and tangible than other lecturers. His style was more to add some animation and additional information to the book material rather than simply presenting facts that were already presented in the book. I may be in a minority of students who feel this way, but I found his illustrations and notes on the whiteboard to be more helpful than the slides, as most of the slides simply contained information and diagrams already available to us in the textbook. His lectures made it seem like we were actually in a class rather than watching an automated online lecture just repeating the facts.	Just a quick note, I found that we went through a lot of material in some slides and it would require a lot of note taking. At times, there would be new terms that were explained and it would be nice if those terms could somehow be integrated into the slide because trying to figure out how to spell them and then defining them would cause me to have to pause the lecture for long periods of time and it would take me close to double the time to get through the lecture.
My first UofT web course is an experience indeed. One that has left me realizing how much easier a full course taken on campus would be.	…more TA hours. due to schooling and work, i was unable to attend even one TA session this term and i think it would've been beneficial to me if i had the opportunity.

4. Discussion

An effective online course is an integration of several different web tools and resources for students to learn course material [8]. For instance, the incorporation of a discussion board in the online PSL course has permitted frequent peer collaboration. This has proven to be a very effective learning method and tool for many students (*Table 8*). Students helped their peers discuss difficult concepts and confirm course information (e.g. number of questions on next quiz). While students can be identified by name, there are no other identifiers such as age or race. This may have prevented the social stigma that may be involved in an in-class course. In the online realm, all students can participate and interact but in the in-class format, some students (e.g. mature students) may feel uncomfortable to interact with other students [3]. This may have had an impact on student performance because the online format may have provided a more accepting and relaxing environment for interaction [9]. Also, with consistent monitoring by TAs and lecturers, participants did not have to worry about the integrity of information posted on the discussion board. Lecturers would clarify any incorrect information posted. Thus, many students have found the discussion board a valuable learning aid (*Table 8*). Flash video lectures as a learning tool have definitely made a difference for many students. Students voiced in survey comments that lecture videos have allowed them to take better notes, revisit certain lecture concepts and increase retention of course material. Though there is flexibility, the lecture videos are still offered only for a restricted time period (three lectures in one week) to promote the same level of discipline as the in-class format.

Despite the convenience and flexibility of the online course, there were still some areas for improvement in the course. We had hoped that the course flexibility and various forms of assistance (TAs, lecturers, peers) would adjust for any age or learning style discrepancies. However, some students, in particular MAC (operating system) users have found some technological features in the course more challenging to use. Steps have already been taken to improve the technology so that it is easier to use and more functional for all types of users (different systems, internet speeds). Upon review of survey results, other negative comments were mainly attributed to individual poor performance such as the “questions in the assessment were too hard”, “there should be some sample questions provided”, “the assessment goes beyond the lecture.” These are common responses that the in-class courses of the University also receive in their course surveys. In response, an online practice quiz and more sample questions will be integrated for the next session. Also, the introductory lecture will inform students from the beginning, that the course goes beyond memorization and requires application of knowledge and their understanding of course material. Students have also noted in the survey that they appreciated certain lecturers who responded to their questions (via email) promptly. Those who did not receive responses (at all or as quickly) commented on the lack of interaction between them and their professors. In the next session, increased lecturer participation in supporting students via email and the discussion board will be strongly encouraged. Finally, although it has been discovered that overall, the online course did provide a positive social experience (Table 8), there are still a few issues identified from the evaluation that need to be addressed further, such as increased interactivity with other students and TAs. Likely this

will be addressed in future sessions by introducing more topics on the discussion board, perhaps unrelated to course material such as personal interests and hobbies or discussions of current events. Also, an introduction of increased tutorial hours with the TA may help the students who have noted the tutorial hours being incompatible with their schedule.

Positive and negative comments aside, an overall analysis of student grades in the online and in-class version has shown that there is not a significant difference in the average grades or grade distribution between the students in the two courses. Final grade differences were statistically insignificant (*Fig. 4*). In addition, when the letter grades of the two courses were compared, we found that the distribution pattern of the grades was similar, suggesting that the online course was just as effective in student learning and performance. Also, looking at the distribution of online quiz grades from the online PSL course, the students consistently improved throughout the course and seemed to show a learning curve (*Fig. 3*). Teaching by lecturers did not seem to be compromised online, as students responded with positive ratings for clarity, delivery and lecturer enthusiasm (a factor students considered critical for their interest in the subject) (*Fig. 5*). Also, the lecturers were still highly regarded by students in terms of contributing to student success in the course and lecturer enthusiasm and teaching quality remained unscathed by using an online medium to communicate (*Fig.8* and student comments).

Likely, the online course has effectively delivered the same material with additional benefits to student studying habits (Table 8). Students had discussed in the survey the many benefits of the course towards their learning, including factors such as convenience, a suitable pace for their own learning and the easily accessible lectures. The student surveys showed that the student learning environment was not compromised in any way when learning the material online. Additional reasons for the similarity in grades between the online and in-class course may be attributed to the two course populations (Fig. 1). A majority of the students in the online PSL course want to apply to a professional healthcare program of some kind. Students in this group are motivated to strive for higher grades to achieve their career of choice. The in-class PSL course however, has a diverse population of specialty and professional programs such as includes pharmacy, physical education, nuclear science, biomedical engineering etc. This group may have achieved their program of choice, but having been accepted into the program, they are likely very strong students who may have retained the level of competence and study habits they had prior to acceptance. Thus, they were still achieving similar averages in the in-class PSL course.

The higher grades of some individual students in the online course (performed better than in-class students) may be attributed to the flexibility in the course leading to greater time for studying. For instance students may not have to commute (to campus) and they can study the material at their own pace, at a time and location most suitable for their individual learning. They can also re-play lecture videos when desired, a feature in-class students most certainly do not have .There may be an age or learning pattern difference within the online PSL population, but we attempted to adjust for possible discrepancies through flexible timing (lectures and online evaluations) and consistent assistance from TAs, lecturers and peers for support. Individual online students who generally did worse than in-class students may have had difficulty with the course material conceptually and/or they had trouble with the online format of the course or the technology. The use of the technology was a common complaint for some individuals in the class. We could surmise that this could be attributed to the heterogeneity in age range of the student population, with the older population potentially having more difficulty with the technology. Without tangible data this is purely supposition and would require further investigation. Some of these “lower performance” students may also be those who are just taking the online course for personal interest (Fig.1), so grades were an insignificant motivating factor for them. They simply appreciated learning something about the human body through an easy to access medium. Finally, there was some complaint about the lack of face-to-face interactions. The use of discussion boards, chat and email may make up for interaction between peers or lecturers, but for some students it may not replace interaction in person. This population of students may be interacting on-campus or in person via study groups, discussing lecture content outside the realm of the physiology course. Through email correspondence, we have also learned that many of these students have used the discussion board to create study groups through online mediums such as webcam applications.

5. Conclusion

Our results indicate there were no significant differences in grades (average and distribution) between the online and in-class format. Given the diverse background, this result suggests that the online version of the physiology

course is just as effective in delivering the course material and the students taking the online course have learned the material just as effectively as the in-class students. Student performance and learning experience was not compromised by taking the course through an online format. Depending on student preferences, some students may have even found the online course to offer additional benefits such as convenience and flexibility. Through the online format, students expressed greater ease in controlling the pace at which they learn the course material. They have also found the flexibility in the course allowed them to better balance their other commitments and priorities. Moreover, our results indicate that the online course offered an intellectually challenging forum that elicited critical thinking, promoted problem solving skills and created a social arena for a diverse set of students to interact.

Results from the student survey demonstrated that lecturers were effective in delivering the course material and instructor teaching was not affected through online lecture videos as opposed to "live" teaching in the lecture hall. A comparison of the online and in-class student survey results for the same lecturer showed negligible differences. In addition, the online course in general was favourably rated and the majority of the students would take another online course offered by University of Toronto again. Through open-ended questions (survey) and email correspondence, we also found that that simple strategy like incorporating frequent online quizzes (something that is difficult to do in in-class lectures) proved effective in making sure that the students were keeping up with the course load. However, we also found that there are issues that need to be addressed regarding communication and support for labs and evaluations. We found that there is potential for further improvement in some of the learner-learner interactions, which will be one of our next steps. We have already begun to hold live meet-and-greet sessions and this has resulted in strong positive feedback from the students.

The success we have experienced in this course has allowed us to predict the possibility that online courses may pave the way in pedagogical methods in the future, providing convenience, distant education and a valuable learning experience [10] .

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